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**Physiological, kinematic, and electromyographic responses to kinesiology-type patella  
tape in elite cyclists**

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physiology

**CONFLICT OF INTEREST**

None.

**FINANCIAL DISCLOSURE**

None.

28    **ABSTRACT**

29

30    Kinesiology-type tape (KTT) has become popular in sports for injury prevention,  
31    rehabilitation, and performance enhancement. Many cyclists use patella KTT; however, its  
32    benefits remain unclear, especially in uninjured elite cyclists. We used an integrated  
33    approach to investigate acute physiological, kinematic, and electromyographic responses to  
34    patella KTT in twelve national-level male cyclists. Cyclists completed four, 4-minute  
35    submaximal efforts on an ergometer at 100 and 200 W with and without patella KTT.  
36    Economy, energy cost, oxygen cost, heart rate, efficiency, 3D kinematics, and lower-body  
37    electromyography signals were collected over the last minute of each effort. Comfort levels  
38    and perceived change in knee stability and performance with KTT were recorded.  
39    The effects of KTT were either unclear, non-significant, or clearly trivial on all collected  
40    physiological and kinematic measures. KTT significantly, clearly, and meaningfully  
41    enhanced *vastus medialis* peak, mean, and integrated electromyographic signals, and *vastus*  
42    *medialis-to-lateralis* activation. Electromyographic measures from *biceps femoris* and  
43    *biceps-to-rectus femoris* activation ratio decreased in either a significant or clinically  
44    meaningful manner. Despite most cyclists perceiving KTT as comfortable, increasing  
45    stability, and improving performance, the intervention exerted no considerable effects on all  
46    physiological and kinematic measures. KTT did alter neuromuscular recruitment, which has  
47    potential implications for injury prevention.

## 48 INTRODUCTION

49 Many health professionals, athletes, and coaches use kinesiology-type tape (KTT), with the  
50 intent to manage musculoskeletal sport injuries; however, growing evidence suggests no  
51 additional benefit from KTT application compared to placebo taping or active control  
52 treatment methods when managing musculoskeletal conditions (Ouyang et al., 2018,  
53 Williams et al., 2012). On the other hand, several beneficial effects from KTT application  
54 have been reported, including enhancement in muscle activation (Gilleard et al., 1998);  
55 improved biomechanics, joint, and patella alignment (Lyman et al., 2017, Merino-Marban et  
56 al., 2013); and decreased pain (Bockrath et al., 1993, Merino-Marban et al., 2013). It is  
57 worth noting, however, that many studies report no effect from KTT on these measures  
58 (Halski et al., 2015) or athletic performance (Lins et al., 2013, Reneker et al., 2018).  
59 Underlying reasons for such contrasting scientific findings likely include the varied  
60 application methods, differences in the mechanical properties of KTT across brands  
61 (Matheus et al., 2017), targeted population, and individuals' perceived benefits of KTT with  
62 a potential for placebo effect (Mak et al., 2018) .

63

64 Cycling is a popular recreational and competitive sporting activity worldwide, and a  
65 common exercise modality used during rehabilitation. At an elite level, athletes and coaches  
66 continually seek for ways to improve performance through marginal gains and prevent the  
67 occurrence of injuries. KTT is routinely used by coaches and athletes as an ergogenic aid  
68 (Reneker et al., 2018), with various forms of taping employed to prevent injury occurrence  
69 or recurrence (Zech and Wellmann, 2017). Given that up to 94% of professional cyclists  
70 suffer from at least one overuse injury annually (Silberman, 2013), the visible increase in  
71 use of KTT amongst elite cyclists for prophylactic purposes is not surprising.

72

73 Taping or bracing are frequently used to alleviate patellofemoral pain (PFP) symptoms and  
74 can impact knee motion during cycling (Theobald et al., 2012). Non-specific KTT  
75 application has been shown to be as effective as specific application for reducing pain and

76 inducing significant changes in lower-body cycling biomechanics in a symptomatic  
77 population group (Theobald et al., 2014). However, any potential positive effect of taping on  
78 energy cost of cycling, neuromuscular recruitment patterns, and performance of  
79 asymptomatic high-level cyclists has not been examined, despite the visibly increased  
80 prevalence of use in the cycling community and KTT marketing campaigns.

81

82 Using an integrated approach, our aim was therefore to investigate the acute physiological,  
83 kinematic, and electromyographic outcomes in response to applying KTT to the knee of elite  
84 cyclists. As perceptions may influence outcomes of interventions, individual perceptions  
85 were also assessed. We hypothesised that taping would be accompanied by changes in  
86 muscle recruitment patterns, cycling economy and efficiency, and perceived stability that  
87 have the potential to modulate cycling performance.

88

## 89 **MATERIALS & METHODS**

### 90 *Participants*

91 All male cyclists of the National Cycling Team training at the National Sports Institute for  
92 Malaysia ( $n = 12$ ) were invited and accepted to participate in this study. These 12 national  
93 cyclists (mean  $\pm$  standard deviation (SD): age,  $21.7 \pm 2.8$  years; body mass,  $65.6 \pm 5.4$  kg;  
94 and height,  $172.7 \pm 3.4$  cm) with at least four years of training experience provided written  
95 informed consent to participate in this study, which adhered to The Code of Ethics of the  
96 World Medical Association (*Declaration of Helsinki*) and was approved by our Institutional  
97 Ethical Review Board (ISNRP 29/2015). Inclusion criteria were cyclists training at the  
98 National Sports Institute of Malaysia for the National Cycling Team, good self-reported  
99 general health, and at least 18 years of age. Cyclists with current or recent ( $< 1$  month)  
100 musculoskeletal injuries, joint pathologies, or medical contraindications to physical exertion  
101 were excluded.

102

### 103 *Design*

104 All cyclists attended 3 sessions at the biomechanics laboratory of the National Sports  
 105 Institute of Malaysia, one week apart. The first two weeks were familiarization sessions and  
 106 the third week was used to investigate the acute effects of KTT application through a  
 107 repeated-measures randomized experimental study design.  
 108  
 109 Given that ergometer versus outdoor cycling can affect cycling physiological measures  
 110 (Bertucci et al., 2012) and pedalling biomechanics (Bertucci et al., 2007), cyclists brought  
 111 their road bikes to the laboratory the first week of testing. Bike setup parameters were  
 112 recorded and employed to individualize setup on a Lode cycling ergometer (Excalibur Sport,  
 113 Lode B.V., Groningen, Netherlands), with all cyclists using their habitual cleats. The final  
 114 ergometer setup was recorded and used across the three weeks. Baseline demographics,  
 115 including leg dominance (self-perceived stronger cycling side), were recorded. Body mass  
 116 (kg) was measured weekly and subsequently used to calculate relative physiological  
 117 variables.  
 118  
 119 Cyclists began all sessions with a 2-min cycling warm-up on the ergometer after being set-  
 120 up with the monitoring equipment. Cyclists then performed a submaximal 4-minute cycling  
 121 effort at 100 W, followed immediately by a second submaximal 4-minute cycling effort at  
 122 200 W. The efforts were completed without KTT during the familiarization weeks, and  
 123 twice on the third week: once with and once without KTT. The no tape (NT) and KTT  
 124 conditions were completed in a block-randomized order and separated by a 5-minute passive  
 125 seated rest. Thus, all cyclists completed four 4-minute efforts: NT 100 W, NT 200 W, KTT  
 126 100 W, and KTT 200 W. The powers of 100 and 200 W were selected to ensure that cycling  
 127 efforts were below the anaerobic threshold and to compute delta efficiency (Coyle et al.,  
 128 1992) (see **Physiology**). Furthermore, the application of patella KTT at these powers has  
 129 been shown to alter lower-body cycling biomechanics in previous studies (Theobald et al.,  
 130 2014), with these power levels set alongside the National Cycling Team of Malaysia to  
 131 inform their practice and use of KTT application in longer steady-state riding situations.

132

### 133 *Taping method*

134 The taping application we used was based on a method previously reported to induce  
135 changes in cycling biomechanics within the power ranges here examined (Theobald et al.,  
136 2012, Theobald et al., 2014). With cyclists seated on the ergometer with the leg at the  
137 bottom of their power stroke , a strip of KTT (RockTape™, RockTape Inc., California) of  
138 length equal to 50% of individual knee circumference was applied on to the centre of the  
139 patella with light tension (approximately 25% of stretch to the tape). The medial and lateral  
140 tape edges were aligned with the medial and lateral knee-joint lines (**Figure 1**). The same  
141 experienced physiotherapist applied the tape to all cyclists. This simple KTT method (i.e.,  
142 across the patella) was selected given its ease-of-use and findings from previous studies  
143 indicating that such a method impacts cycling biomechanics in a manner that is comparable  
144 to that of a more intricate KTT application method (Theobald et al., 2014). Given the  
145 minimalist KTT method applied, a “placebo” taping method was not implemented.

146 \*\*\***Insert Figure 1**\*\*\*

147

### 148 *Physiology*

149 Oxygen consumption ( $\text{VO}_2$ ), carbon dioxide output ( $\text{VCO}_2$ ), and heart rate were monitored  
150 throughout the 4-minute experimental efforts using a calibrated K5 wearable metabolic  
151 technology system (COSMED, Rome, Italy). All physiological measures were averaged over  
152 the last minute where steady state was observed.  $\text{VO}_2$  was used to determine steady-state  
153 relative oxygen cost ( $\text{mL/kg/km}$ ) and absolute cycling economy ( $\text{W/L/min}$ ). From the  $\text{VO}_2$   
154 and  $\text{CO}_2$  data, the relative energy cost of efforts ( $\text{kcal/kg/km}$ ) was estimated using the energy  
155 expenditure equations described by Jeukendrup and Wallis (2005). Gross efficiency (%) and  
156 delta efficiency (%) were calculated as suggested by Coyle et al. (1992) using the ratio of  
157 work accomplished (watts converted to  $\text{kcal/min}$ ) to absolute energy cost ( $\text{kcal/min}$ ) for  
158 gross efficiency, and the reciprocal of the slope that describes the relationship between the  
159 absolute energy cost and work accomplished for delta efficiency.

160

### 161 *Kinematics*

162 Lower-body, trunk, and pelvis movements were captured in 3D during the last minute of  
163 each 4-minute cycling effort at 300 Hz using 10 Oqus 300 infrared cameras and the Qualisys  
164 Track Manager Software version 2.12 (Qualisys AB, Gothenburg, Sweden). Forty-six retro-  
165 reflective markers (12 mm in diameter) were affixed to the skin, clothes, and shoes of  
166 cyclists based on the Calibrated Anatomical System Technique (Cappozzo et al., 1997) and  
167 following established guidelines (Grood and Suntay, 1983). All 46 markers were used for  
168 static calibration; whereas 14 markers were removed for the cycling efforts (**Figure 2**).

169

170 \*\*\***Insert Figure 2**\*\*\*

171

172 An 8-segment biomechanical model with 6 degrees of freedom at each joint was constructed  
173 in Visual3D Professional™ Software version 5.02.30 (C-Motion Inc., Germantown, MD,  
174 USA), with the local coordinates of the trunk, pelvis, thighs, shanks, and feet derived from  
175 the static calibration and the pelvis used to define hip-joint centres (Bell et al., 1989). Prior  
176 to each session, the measurement volume was calibrated using a 750-mm wand and L-frame  
177 that defined the Cartesian origin of the laboratory. Cyclists were then requested to sit on the  
178 saddle of the ergometer, with legs hanging to the side, and remain motionless to allow static  
179 calibration.

180

### 181 *Electromyography*

182 The electromyography (EMG) signals from the following four muscles were recorded on  
183 both the dominant and non-dominant sides: *vastus medialis* (VM), *vastus lateralis* (VL),  
184 *rectus femoris* (RF) and *biceps femoris* (BF). Signals were recorded using Noraxon's Dual  
185 EMG surface Ag/AgCl electrodes (17.5 mm inter-electrode distance), wireless EMG  
186 sensors, and Desktop DTS data logger (Noraxon USA Inc., Scottsdale, AZ). EMG data were  
187 sampled at 1500 Hz, low-pass filtered at 500 Hz, and digitally integrated through the



188 Qualisys Track Manager Software. Skin preparation and electrode positioning followed the  
189 Surface EMG for Noninvasive Assessment of Muscle (Hermens et al., 2000), International  
190 Society of Electrophysiology and Kinesiology (Merletti and di Torino, 1999), and published  
191 protocols (Gilleard et al., 1998). Cyclists completed a few cycling revolutions before  
192 experimentation to allow visual inspection of EMG signal quality. Sensors were checked and  
193 reapplied if artefacts were observed.

194

### 195 ***Perception***

196 Perceived change in knee stability and performance with KTT compared to NT was assessed  
197 at the end of the experimental session using a 5-point Likert (1932) Scale from negative (1)  
198 to positive (5) perception, with the mid-point value representing no change (3). Comfort  
199 level of KTT was also assessed using a similar method. Anchor points ranged from very  
200 uncomfortable (1), much less stable (1), and much worse (1) to very comfortable (5), much  
201 more stable (5), and much better (5) for comfort, knee stability, and performance,  
202 respectively.

203

### 204 ***Data processing***

205 Kinematic and EMG data were exported to the C3D format and processed in Visual 3D.  
206 Marker data were filtered using a 4<sup>th</sup> order zero-lag 15 Hz Butterworth bidirectional filter.  
207 Kinematic parameters were then calculated using rigid-body analysis and Euler angles  
208 obtained from the static calibration. Hip, knee, and ankle angles in the sagittal (flexion-  
209 extension), coronal (adduction-abduction), and transverse (internal-external rotation) planes  
210 were calculated using an x-y-z Cardan sequence equivalent to the Joint Coordinate System  
211 (Grood and Suntay, 1983), with the pelvis angles in the sagittal (anterior-posterior), coronal  
212 (dominant, non-dominant obliquity), and transverse (dominant, non-dominant rotation)  
213 planes defined relative to the laboratory. Trunk angles in the sagittal (flexion-extension),  
214 coronal (dominant, non-dominant lateral flexion), and transverse (dominant, non-dominant  
215 rotation) planes were also defined in relation to the laboratory coordinates. Data were

216 divided into movement cycles and time-normalized based on maximal knee flexion events.  
217 Ensemble-average kinematic curves were generated for each participant and cycling effort,  
218 and range of motion (ROM) values extracted.  
219  
220 EMG signal data were zeroed to remove any baseline offset and a 20-Hz high-pass filter  
221 applied to remove movement artefacts. Signals were subsequently rectified and linear  
222 envelopes generated by smoothing the data using a low-pass, 4<sup>th</sup> order, zero-lag 15 Hz  
223 Butterworth filter. The linear envelope for each muscle was then normalized to the highest  
224 observed signal across all four conditions examined (% max). Similar to the kinematic data,  
225 ensemble-average EMG signal curves time normalized to maximal knee flexion events were  
226 generated from which mean and peak EMG signal values were extracted. An integrated  
227 EMG (iEMG) signal was also generated by integrating the linear envelop from the start to  
228 the end of each movement cycle, which was then normalized to the maximal observed iEMG  
229 across all four efforts (% max).

230

### 231 *Statistical analysis*

232 Mean and SD values were computed for all parameters for both the 100 and 200 W efforts  
233 and dominant and non-dominant sides. Changes in mean ( $\Delta_{\text{mean}}$ ) and standardized effect  
234 sizes (ES) were computed to quantify the acute effect of KTT; with ES considered small,  
235 moderate, large, and very large when reaching thresholds of 0.2, 0.6, 1.2, 2.0, and trivial  
236 when  $< 0.2$  (Smith and Hopkins, 2011). An effect was deemed ‘clear’ when its 90%  
237 confidence limit did not overlap the thresholds for small positive and small negative effects  
238 (i.e., 5%); and ‘likely’ to be clinically meaningful when its probability exceeded 75% (Smith  
239 and Hopkins, 2011).

240

241 Paired *t*-tests were used to investigate differences between the tape and no-tape condition for  
242 the measures of interest, with the threshold for statistical significance set at  $P \leq 0.05$ . All

243 data were analysed using customized statistical spreadsheets (Microsoft Excel 2013,  
244 Microsoft Corp, Redmond WA, USA).

245

## 246 **RESULTS**

### 247 *Physiology*

248 KTT had clear and trivial effects on oxygen cost and energy cost measures at 200 W that did  
249 not reach statistical significance. The effect of KTT on all other physiological parameters  
250 was unclear or unlikely, and not statistically significant (**Table 1**).

251

252 **\*\*\*Insert Table 1\*\*\***

253

### 254 *Kinematics*

255 The clear and likely effects of KTT on ROM values at 100 W (**Table 2**) and 200 W (**Table**  
256 **3**) were trivial, except for the mean ankle ROM in the transverse plane at 100 W on the  
257 dominant side, where a small non-significant increase was noted (ES, 0.35; *P*, 0.097; **Table**  
258 **2**). In all other cases, the effect of KTT was unclear or unlikely, and not statistically  
259 significant.

260

261 **\*\*\*Insert Table 2\*\*\***

262

263 **\*\*\*Insert Table 3\*\*\***

264

### 265 *Electromyography*

266 The effect of KTT on certain VM, VM-to-VL ratio, BF, and RF-to-BF ratio measures were  
267 clear, likely, and significant at 100 W (**Table 4**) and 200 W (**Table 5**). Changes primarily  
268 affected the efforts performed at 100 W.

269

270 At 100 W, the effect of KTT on the non-dominant side was clear, likely, and significant for  
271 increasing VM peak (ES, 1.35;  $P$ , 0.044), and decreasing the RF-to-BF ratio peak (ES, -0.42;  
272  $P$ , 0.021) and mean (ES, -0.62;  $P$ , 0.016) measures. There was also clear and likely non-  
273 significant increases in VM iEMG (ES, 0.72;  $P$ , 0.128); and VM-to-VL ratio peak (ES, 2.20;  
274  $P$ , 0.118), iEMG (ES, 1.26;  $P$ , 0.097), and mean (ES, 1.21;  $P$ , 0.08) measures.

275

276 At 100 W, the effect of KTT on the dominant side was clear, likely, and significant for  
277 increasing VM iEMG (ES, 0.98;  $P$ , 0.024) and mean (ES, 0.95;  $P$ , 0.030); increasing VM-to-  
278 VL ratio peak (ES, 2.19;  $P$ , 0.009), iEMG (ES, 1.63;  $P$ , 0.020), and mean (ES, 1.21;  $P$ ,  
279 0.029); and decreasing BF mean (ES, -0.36;  $P$ , 0.047) measures. There was also a clear and  
280 likely non-significant increase in VM peak (ES, 0.87;  $P$ , 0.056); and decrease in RF peak  
281 (ES, -0.39;  $P$ , 0.135) and mean (ES, -0.51;  $P$ , 0.137) measures.

282

283 **\*\*\*Insert Table 4\*\*\***

284

285 At 200 W, the effect of KTT on the non-dominant side was clear, likely, and significant for  
286 increasing VM iEMG (ES, 1.04;  $P$ , 0.014). There was also a clear and likely non-significant  
287 increase in VM peak (ES, 0.92;  $P$ , 0.122) and mean (ES, 0.92;  $P$ , 0.088); increase in VM-to-  
288 VL ratio peak (ES, 1.41;  $P$ , 0.157), iEMG (ES, 0.88;  $P$ , 0.124), and mean (ES, 2.07;  $P$ ,  
289 0.098); and decrease in BF mean (ES, -0.39;  $P$ , 0.194). At 200 W, there was a clear and  
290 likely non-significant effect of KTT on decreasing peak BF (ES, -0.69;  $P$ , 0.077) measures.

291

292 **\*\*\*Insert Table 5\*\*\***

293

## 294 ***Perception***

295 Most cyclists perceived KTT as being comfortable, providing additional stability to the  
296 knee, and enhancing performance (**Figure 3**). However, three cyclists felt that KTT was  
297 uncomfortable, with one cyclist feeling more unstable with KTT.

298

299 \*\*\*Insert Figure 3\*\*\*

300

## 301 **DISCUSSION**

302 Despite most cyclists perceiving enhanced performance and knee stability with patella KTT;  
303 the effects of the intervention were either unclear, non-significant, or clearly trivial for all  
304 physiological and kinematic measures, except for a small non-significant increase in ankle  
305 ROM on the dominant side in the transverse plane at 100 W. KTT affected the EMG-  
306 determined muscle activation patterns the most, notably increasing VM and VM-to-VL ratio  
307 measures at both powers; and decreasing BF and RF-to-BF ratio measures. Overall, our  
308 findings indicate a potential for patella KTT to alter the neuromuscular recruitment patterns  
309 of elite cyclists with no current musculoskeletal injury at low powers, which could have  
310 implications in the prevention of overuse injuries.

311

### 312 *Physiology*

313 Cycling biomechanics and neuromuscular function can alter energy cost, oxygen cost, and  
314 cycling efficiency. For instance, cycling in a more aerodynamic than upright position can  
315 increase oxygen cost by 1.5% (Gnehm et al., 1997). This increase is speculated to result in  
316 part from a shift in mean hip-joint angles towards greater flexion, which alters the operating  
317 points of the hip- and knee-joint muscles on the force-velocity and force-length curves, as  
318 well as an increase in hip adductor activation to prevent out-of-plane motion in extreme hip  
319 flexion. The biomechanical and neuromuscular differences associated with changing cycling  
320 positions from aerodynamic to upright are inherently much larger than those potentially  
321 resulting from KTT application, especially proximally at the trunk, pelvis, and hip (Dorel et  
322 al., 2009). It is likely that the neuromuscular changes observed here in VM, VM-to-VL ratio,  
323 BF, and RF-to-BF ratio measures with KTT were not sufficient to cause significant or clear  
324 alterations in the physiological parameters monitored.

325

326 ***Kinematics and muscle activation***

327 Ideally, the legs should act as pistons during cycling (Sanner and O'Halloran, 2000), with  
328 lower-body motion mainly directed upwards and downwards, and cyclists in a saddle  
329 position that allows knee extension with minimal valgus angulation. Most studies addressing  
330 lower-body kinematics during cycling have focused on sagittal plane motion, with our  
331 sagittal ROM values agreeing with those typically reported (Bini et al., 2011). Although a  
332 certain amount of 'out-of-plane' motion is anticipated, lower-body misalignment and  
333 excessive out-of-plane motion are reported to contribute to musculoskeletal injuries in  
334 cyclists (Bini et al., 2011, Gregor and Wheeler, 1994). One of the proposed benefits of KTT  
335 is to assist in joint alignment through improvements in proprioception, which in turn can  
336 improve movement patterns and cycling efficiency. Hence, we anticipated less out-of-plane  
337 motion at the knee with KTT; however, such a reduction was not evident.

338  
339 Previous studies have shown that patellar taping can affect movement patterns in both  
340 healthy and symptomatic individuals (Theobald et al., 2014), as well as muscle recruitment  
341 of VM (Gilleard et al., 1998), VL (Gilleard et al., 1998), and RF (Konishi, 2013). These  
342 changes in neuromuscular function are suggested to result from the tactile stimulation of the  
343 skin (Konishi, 2013), rather than by the actual tape configuration or alterations in patellar  
344 positioning (Bockrath et al., 1993). Conversely, several other studies have observed no  
345 effect from therapeutic taping on neuromuscular function (Halski et al., 2015, Lins et al.,  
346 2013), with little evidence supporting improved athletic performance or muscle strength  
347 (Csapo and Alegre, 2015, Lins et al., 2013). Our results support the hypothesis that applying  
348 KTT across the knee stimulates VM activation and increases the VM-to-VL ratio in  
349 asymptomatic elite cyclists during submaximal efforts, without inducing significant or clear  
350 changes in knee biomechanics.

351  
352 The VM muscle is the dynamic medial stabilizer of the patella and functionally important in  
353 aligning the patella within the patella-femoral joint trochlea, which cannot be readily

354 examined using skin-markers and 3D motion capture. Our KTT application had no  
355 mechanical intent, and the altered muscle activation seen here most likely resulted from the  
356 enhanced tactile input that altered the excitability of the central nervous system and  
357 modulated proprioceptive afferent feedback loops (Simoneau et al., 1997). The enhanced  
358 VM activation seen in our cyclists when wearing KTT could be beneficial for preventing  
359 patellofemoral pain given that VM is important for the dynamic alignment of the patella.  
360 Studies have shown that individuals with PFP exhibit lower activity levels of all vastus  
361 muscles during walking (Powers et al., 1996) and VM-to-VL ratios across a range of  
362 functional and isometric contraction tasks (Souza and Gross, 1991). Furthermore, delayed  
363 onset of EMG activity of the VM in relation to VL (-0.67 ms) has been identified as a  
364 contributing factor to the development of PFP in one prospective study (Van Tiggelen et al.,  
365 2009). That said, prospective studies on this topic in elite cyclists are needed to confirm the  
366 prophylactic effect of patella KTT on knee injury occurrence in this population group.

367

368 Although the VM and VL muscles play a critical role in power output during cycling, there  
369 is also a high activation of the RF and BF muscles (Akima et al., 2005), with proper co-  
370 activation of the hamstrings, which has been suggested to reduce stress at the knee during  
371 cycling (So et al., 2005). Hence, reducing the RF-to-BF ratio may have meaningful clinical  
372 implications for athletes who exhibit imbalances between knee extensor and flexor strength,  
373 poor coordination, and non-optimal activation patterns (i.e., athletes who are quadriceps  
374 dominant). With KTT application; there was a clear, likely, and significant decrease in mean  
375 BF signals on the dominant side, as well as and peak and mean RF-to-BF ratio values at 100  
376 W on the non-dominant side; with only a small non-significant decrease in RF-to-BF mean  
377 observed at 200 W. Despite our results indicating some potential for alterations in RF-to-BF  
378 muscle activation patterns, larger sample sizes would be needed to confirm outcomes and  
379 implications of these changes.

380

381 Most of the neuromuscular effects observed at 100 W became unclear and non-significant at  
382 200 W, pointing to an interaction effect between power output and neuromuscular responses  
383 to taping. It is well established that muscle contraction forces increase primarily due to an  
384 increase in the number of motor units active and associated firing rates in a non-linear  
385 fashion (Merletti and Parker, 2004), with previous cycling studies showing progressive  
386 increase in muscle activation with progressive loads from ~150, 220, 290, and 370 W  
387 (Carpes et al., 2010a). It is plausible that the effect of KTT on the neuromuscular control  
388 diminished with increased overall muscle recruitment, explaining the attenuated effects of  
389 KTT at 200 W; however, the underlying mechanisms are unclear given the paucity of  
390 literature investigating the effect of KTT at different contraction levels and loads within a  
391 given exercise.

392

393 The non-dominant and dominant holistically demonstrated comparable responses to KTT,  
394 although some clear effects and significant findings were only detected on one side. This  
395 discrepancy might be linked to preferred movement patterns of our cyclists, previous injuries  
396 with residual neuromuscular inhibition or muscle weakness, or our limited sample size that  
397 reduced our statistical power. Most studies suggest that bilateral pedalling asymmetries in  
398 terms of power, work, or force increase as the workload decreases (Carpes et al., 2010b),  
399 which might explain some of the differential responses between legs that were observed.  
400 However, given that work was controlled, and power and force not monitored, the  
401 mechanistic reasons behind the between-leg differences remain undetermined.

402

#### 403 ***Perception***

404 Applying RockTape™ to the anterior aspects of the arms and legs and posterior aspects of  
405 the neck and back has previously been shown to decrease ‘overall’ and ‘chest’ ratings of  
406 perceived exertion of trained cyclists, but not alter ‘arm’ and ‘leg’ ratings of perceived  
407 exertions or gross efficiency (Miller et al., 2015). The physiological findings from this same  
408 investigation were unable to support improved athletic performance with RockTape™ use



409 (Miller et al., 2015). Although most of our cyclists perceived additional knee stability and  
410 enhanced performance with KTT; the biomechanical and physiological findings were unable  
411 to support that KTT improved knee stability or economy, with KTT application exerting  
412 unclear, non-significant, or clearly trivial effects on knee ROM and physiological measures.  
413 It is likely that our cyclists' perceptions result from the EMG changes observed or a placebo  
414 effect (Mak et al., 2018). Nonetheless, KTT application may still provide some benefits to  
415 certain cyclists given the changes observed in the EMG parameters, notably the increased  
416 VM activation and alterations in the VM-to-VL and RF-to-BF activation ratios.

417

#### 418 *Individual responses*

419 One cyclist perceived KTT as uncomfortable and decreasing knee stability. Nonetheless, this  
420 particular cyclist felt that KTT improved his performance. This cyclist's data indicated a  
421 slight worsening in cycling economy measures at 200 W, with a general increase in knee  
422 ROM in all planes of motion with KTT. Simultaneously, EMG signals for VM, VL, and RF,  
423 and the VM-to-VL and RF-to-BF ratios increased with KTT, and decreased for BF. In this  
424 particular case, perceptions matched well with biomechanical findings, but not necessarily  
425 with the physiological ones. In contrast, several cyclists who perceived an increased knee  
426 stability, an improved performance, and felt comfortable with KTT application showed  
427 'negative' responses, with their perceptual ratings disagreeing with their objective measures.  
428 Hence, although individual data suggest the presences of 'positive responders', 'negative  
429 responders', and 'non-responders', we were unable to clearly define subgroups from the  
430 subjective data collected.

431

#### 432 *Limitations*

433 Small sample sizes are an inherent limitation in any high performance sport environment,  
434 which reduced our statistical power. All male National Team cyclists available for testing  
435 accepted to participate. Our sample size could not be increased further without  
436 compromising the external validity of our findings (i.e., testing lower-level cyclists). Future

research should examine the repeatability of the effect of KTT application and the potential for any long-term effect or habituation to KTT more thoroughly. We tested only elite male cyclists since the national-level female cyclists were training overseas at the time of data collection and thus the findings may be specific to this population. Female athletes differ physiologically, morphologically, and with respect to injury risk factors compared to male athletes, therefore specific investigations of how female cyclists respond to KTT are warranted. We also acknowledge that the power settings selected were submaximal for elite cyclists and that responses at higher powers might differ. Using lower powers was a necessity to calculate steady state oxygen consumption, economy, and efficiency, and for practical relevance to the National Cycling Team of Malaysia. It should be noted however, that during tour events cyclists often perform for prolonged periods at relatively low levels of power production. For example, Alexander Kristoff's average power output during the first hour of Stage 4 of the 2017 Tour de France was 118 W and his average power output over the entire 4:53:54 of the stage (in which he finished second), was 189 W ([www.trainingpeaks.com](http://www.trainingpeaks.com)). Finally, given the minimalist taping technique applied, it was not possible to implement a "placebo" taping method or different taping configurations to confer differences in proprioceptive input.

## CONCLUSIONS

Most cyclists perceived increased performance and knee stability with patella KTT, but the intervention had little impact on physiological measures and mostly trivial non-significant effects on knee ROM values. However, patella KTT decreased ROM at the pelvis and trunk at the higher power and appeared to stabilize the segments proximally, which could be a favourable adaptation in cyclists (McDaniel et al., 2005). KTT application did alter EMG responses, notably increasing VM activation and altering the VM-to-VL activation ratio at 100 and 200 W, and changes indicating an increase in BF recruitment in relation to RF at 100 W. Our findings imply that there is a potential for patella KTT to alter neuromuscular recruitment patterns in elite uninjured cyclists, which could have implications for injury

465 prevention and especially the development of PFP by assisting with patella alignment and  
466 alleviating knee-joint stress through neuromuscular pathways as opposed to altering knee  
467 biomechanics. As such, the neuromuscular changes we observed indicate that cyclists may  
468 benefit acutely from patella KTT, although the longitudinal effects of KTT use have not yet  
469 been established.

470

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475

476

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**Table 1.** Mean  $\pm$  SD values for oxygen cost (mL/kg/km), energy cost (kcal/kg/km), cycling economy (W/L/min), heart rate (bpm), and gross efficiency (%) in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 and 200 W cycling efforts. Delta efficiency (%) in NT and KTT conditions is also presented. Differences between conditions are expressed using mean change ( $\Delta_{\text{mean}}$ ); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ( $P \leq 0.05$ ) are highlighted in grey.

Parameters	NT	KTT	$\Delta_{\text{mean}}$	ES (threshold)	<i>P</i>
<b>100 W</b>					
<b>Oxygen cost</b>	175.4 $\pm$ 30.6	175.2 $\pm$ 33.5	-0.2 $\pm$ 14.1	-0.01 $\pm$ 0.42 (unclear)	0.963
<b>Energy cost</b>	0.86 $\pm$ 0.15	0.86 $\pm$ 0.16	0.001 $\pm$ 0.07	0.001 $\pm$ 0.43 (unclear)	0.993
<b>Economy</b>	53.4 $\pm$ 5.6	53.6 $\pm$ 5.5	0.2 $\pm$ 4.5	0.03 $\pm$ 0.78 (unclear)	0.885
<b>Heart rate</b>	115.3 $\pm$ 9.8	115.6 $\pm$ 9.5	0.3 $\pm$ 5.8	0.03 $\pm$ 0.58 (unclear)	0.845
<b>Gross efficiency</b>	15.5 $\pm$ 1.6	15.6 $\pm$ 1.6	0.04 $\pm$ 1.31	0.02 $\pm$ 0.79 (unclear)	0.926
<b>200 W</b>					
<b>Oxygen cost</b>	277.3 $\pm$ 48.0	273.4 $\pm$ 46.1	-3.9 $\pm$ 12.6	-0.08 $\pm$ 0.26 (trivial) <sup>§</sup>	0.311
<b>Energy cost</b>	1.37 $\pm$ 0.23	1.35 $\pm$ 0.22	-0.02 $\pm$ 0.06	-0.09 $\pm$ 0.26 (trivial) <sup>§</sup>	0.263
<b>Economy</b>	67.4 $\pm$ 5.2	68.4 $\pm$ 5.9	1.0 $\pm$ 3.1	0.19 $\pm$ 0.54 (trivial)	0.303
<b>Heart rate</b>	147.6 $\pm$ 9.2	146.8 $\pm$ 8.4	-0.8 $\pm$ 6.4	-0.08 $\pm$ 0.70 (unclear)	0.691
<b>Gross efficiency</b>	19.5 $\pm$ 1.5	19.8 $\pm$ 1.7	0.3 $\pm$ 0.9	0.21 $\pm$ 0.54 (small)	0.260
<b>Delta efficiency</b>	26.5 $\pm$ 3.1	27.3 $\pm$ 2.3	0.8 $\pm$ 3.0	0.25 $\pm$ 1.04 (unclear)	0.380

*Note.* An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). <sup>§</sup>Probability of the effect exceeds 75% and is ‘likely’ to be clinically meaningful.



**Table 2.** Mean  $\pm$  SD values for range of motion values ( $^{\circ}$ ) in the sagittal (X), coronal (Y), and transverse (Z) planes in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 W cycling efforts for the dominant (D) and non-dominant (ND) sides. Differences between conditions are expressed using mean change ( $\Delta_{\text{mean}}$ ); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ( $P \leq 0.05$ ) are highlighted in grey.

Joint	Side	Plane	NT	KTT	$\Delta_{\text{mean}}$	ES	<i>P</i>
Ankle	ND	X	19.5 $\pm$ 8.1	19.9 $\pm$ 8.7	0.4 $\pm$ 2.1	0.05 (trivial) <sup>§</sup>	0.517
		Y	5.3 $\pm$ 1.7	5.5 $\pm$ 1.9	0.2 $\pm$ 0.6	0.11 (trivial) <sup>§</sup>	0.289
		Z	5.7 $\pm$ 2.3	5.7 $\pm$ 1.9	0.0 $\pm$ 1.5	0.02 (unclear)	0.920
	D	X	21.4 $\pm$ 4.9	20.3 $\pm$ 6.0	-1.1 $\pm$ 3.9	-0.22 (small)	0.355
		Y	4.3 $\pm$ 1.8	5.0 $\pm$ 1.7	0.6 $\pm$ 1.2	0.35 (small) <sup>§</sup>	0.097
		Z	5.5 $\pm$ 0.7	5.2 $\pm$ 1.0	-0.3 $\pm$ 1.1	-0.44 (unclear)	0.350
Knee	ND	X	76.7 $\pm$ 3.1	76.2 $\pm$ 3.6	-0.5 $\pm$ 1.5	-0.16 (trivial)	0.270
		Y	9.2 $\pm$ 3.6	9.0 $\pm$ 3.3	-0.2 $\pm$ 1.5	-0.04 (trivial) <sup>§</sup>	0.727
		Z	9.2 $\pm$ 4.9	9.3 $\pm$ 3.9	0.1 $\pm$ 2.6	0.03 (unclear)	0.867
	D	X	78.8 $\pm$ 2.3	78.2 $\pm$ 2.2	-0.5 $\pm$ 1.7	-0.23 (small)	0.304
		Y	8.3 $\pm$ 2.6	8.1 $\pm$ 2.3	-0.2 $\pm$ 1.1	-0.08 (trivial) <sup>§</sup>	0.526
		Z	12.3 $\pm$ 5.3	12.4 $\pm$ 4.7	0.0 $\pm$ 1.8	0.003 (trivial) <sup>§</sup>	0.976
Hip	ND	X	48.7 $\pm$ 3.5	48.8 $\pm$ 3.8	0.1 $\pm$ 1.5	0.02 (unclear)	0.901
		Y	6.3 $\pm$ 3.4	6.2 $\pm$ 2.8	0.0 $\pm$ 1.3	-0.01 (trivial) <sup>§</sup>	0.915
		Z	11.5 $\pm$ 3.8	11.4 $\pm$ 4.3	0.0 $\pm$ 1.8	-0.01 (unclear)	0.937
	D	X	47.5 $\pm$ 2.9	47.4 $\pm$ 2.8	-0.1 $\pm$ 1.1	-0.04 (trivial) <sup>§</sup>	0.694
		Y	6.6 $\pm$ 1.8	6.6 $\pm$ 1.9	0.0 $\pm$ 1.4	-0.005 (unclear)	0.983
		Z	10.0 $\pm$ 3.7	9.5 $\pm$ 3.2	-0.5 $\pm$ 1.4	-0.12 (trivial)	0.283
Pelvis		X	8.1 $\pm$ 1.8	8.3 $\pm$ 2.2	0.2 $\pm$ 1.4	0.10 (unclear)	0.647
		Y	3.5 $\pm$ 0.9	3.6 $\pm$ 1.1	0.1 $\pm$ 0.5	0.09 (trivial)	0.561
		Z	3.7 $\pm$ 1.9	3.6 $\pm$ 1.3	-0.1 $\pm$ 2.2	-0.05 (unclear)	0.881
Trunk		X	8.8 $\pm$ 3.9	10.1 $\pm$ 8.2	1.3 $\pm$ 8.9	0.34 (unclear)	0.620
		Y	0.8 $\pm$ 0.2	0.7 $\pm$ 0.2	0.0 $\pm$ 0.1	-0.07 (trivial) <sup>§</sup>	0.643
		Z	8.4 $\pm$ 4.1	9.6 $\pm$ 8.5	1.2 $\pm$ 9.4	0.30 (unclear)	0.663

*Notes.* Sagittal (X): ankle dorsiflexion and plantar flexion, knee and hip flexion and extension, pelvis and trunk anterior and posterior tilt; Coronal (Y): ankle inversion and eversion, knee valgus and varus, hip abduction and adduction, pelvis and trunk non-dominant side and dominant side tilt; Transverse (Z) ankle, knee, and hip internal and external rotation, pelvis and trunk non-dominant side and dominant side rotation. An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). <sup>§</sup>Probability of the effect exceeds 75% and is ‘likely’ to be clinically meaningful.

**Table 3.** Mean  $\pm$  SD values for range of motion values ( $^{\circ}$ ) in the sagittal (X), coronal (Y), and transverse (Z) planes in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 200 W cycling efforts for the dominant (D) and non-dominant (ND) sides. Differences between conditions are expressed using mean change ( $\Delta_{\text{mean}}$ ); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ( $P \leq 0.05$ ) are highlighted in grey.

Joint	Side	Plane	NT	KTT	$\Delta_{\text{mean}}$	ES	<i>P</i>
Ankle	ND	X	21.7 $\pm$ 7.8	22.7 $\pm$ 8.3	1.0 $\pm$ 2.6	0.12 (trivial) <sup>§</sup>	0.235
		Y	5.9 $\pm$ 2.0	6.2 $\pm$ 2.6	0.2 $\pm$ 1.0	0.11 (trivial)	0.450
		Z	5.9 $\pm$ 1.8	5.7 $\pm$ 1.9	-0.2 $\pm$ 1.0	-0.11 (trivial)	0.529
	D	X	24.0 $\pm$ 6.9	24.7 $\pm$ 5.7	0.7 $\pm$ 3.0	0.10 (trivial) <sup>§</sup>	0.435
		Y	4.7 $\pm$ 1.3	4.9 $\pm$ 1.5	0.2 $\pm$ 0.6	0.14 (trivial)	0.342
		Z	6.0 $\pm$ 1.6	5.8 $\pm$ 1.7	-0.2 $\pm$ 0.4	-0.14 (trivial) <sup>§</sup>	0.123
Knee	ND	X	78.4 $\pm$ 3.7	78.9 $\pm$ 3.1	0.5 $\pm$ 1.7	0.14 (trivial)	0.302
		Y	8.3 $\pm$ 2.6	8.2 $\pm$ 2.6	-0.7 $\pm$ 1.4	-0.03 (unclear)	0.849
		Z	9.4 $\pm$ 4.1	8.8 $\pm$ 3.1	-0.6 $\pm$ 1.8	-0.14 (trivial)	0.277
	D	X	80.1 $\pm$ 2.3	80.9 $\pm$ 2.5	0.8 $\pm$ 2.1	0.34 (small)	0.224
		Y	7.7 $\pm$ 2.1	8.1 $\pm$ 2.1	0.4 $\pm$ 0.9	0.19 (trivial)	0.146
		Z	11.5 $\pm$ 4.5	11.2 $\pm$ 4.5	-0.3 $\pm$ 1.6	-0.07 (trivial) <sup>§</sup>	0.496
Hip	ND	X	49.6 $\pm$ 3.9	49.3 $\pm$ 4.5	-0.9 $\pm$ 2.1	-0.07 (unclear)	0.661
		Y	7.4 $\pm$ 3.7	7.4 $\pm$ 3.4	0.0 $\pm$ 1.0	0.001 (trivial) <sup>§</sup>	0.988
		Z	11.5 $\pm$ 3.4	12.1 $\pm$ 3.4	0.6 $\pm$ 1.7	0.18 (trivial)	0.245
	D	X	47.4 $\pm$ 2.8	47.5 $\pm$ 2.4	0.1 $\pm$ 1.4	0.02 (unclear)	0.874
		Y	7.1 $\pm$ 2.5	6.9 $\pm$ 2.2	-0.3 $\pm$ 1.2	-0.10 (trivial)	0.490
		Z	10.3 $\pm$ 3.1	10.4 $\pm$ 3.2	0.1 $\pm$ 1.5	0.03 (unclear)	0.812
Pelvis		X	8.4 $\pm$ 2.4	7.9 $\pm$ 2.2	-0.5 $\pm$ 1.1	-0.19 (trivial)	0.178
		Y	3.5 $\pm$ 1.3	3.7 $\pm$ 1.5	0.2 $\pm$ 0.5	0.14 (trivial)	0.269
		Z	4.0 $\pm$ 1.8	3.6 $\pm$ 1.1	-0.4 $\pm$ 1.8	-0.22 (unclear)	0.447
Trunk		X	9.5 $\pm$ 4.2	8.6 $\pm$ 2.7	-0.9 $\pm$ 3.4	-0.21 (unclear)	0.391
		Y	0.9 $\pm$ 0.5	0.9 $\pm$ 0.3	0.0 $\pm$ 0.3	-0.04 (unclear)	0.834
		Z	8.6 $\pm$ 3.8	7.8 $\pm$ 2.6	-0.9 $\pm$ 3.6	-0.22 (unclear)	0.430

*Notes.* Sagittal (X): ankle dorsiflexion and plantar flexion, knee and hip flexion and extension, pelvis and trunk anterior and posterior tilt; Coronal (Y): ankle inversion and eversion, knee valgus and varus, hip abduction and adduction, pelvis and trunk non-dominant side and dominant side tilt; Transverse (Z) ankle, knee, and hip internal and external rotation, pelvis and trunk non-dominant side and dominant side rotation. An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). <sup>§</sup>Probability of the effect exceeds 75% and is ‘likely’ to be clinically meaningful.

**Table 4.** Mean (%<sub>max</sub>), peak (%<sub>max</sub>), and integrated EMG (iEMG, %<sub>max</sub>) signal values (mean ± SD) for the *vastus medialis* (VM), *vastus lateralis* (VL), *rectus femoris* (RF), and *biceps femoris* (BF) muscles in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 W cycling efforts for the dominant (D) and non-dominant (ND) sides. The VM-to-VL and RF-to-BF activation ratios are also presented. Differences between conditions are expressed using mean change ( $\Delta_{\text{mean}}$ ); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ( $P \leq 0.05$ ) are highlighted in grey.

Muscle	Side	EMG	NT	KTT	$\Delta_{\text{mean}}$	ES (threshold)	<i>P</i>
VM	ND	Peak	29.5 ± 5.9	37.4 ± 5.1	8.0 ± 7.4	1.35 (large) <sup>§</sup>	0.047
		iEMG	39.9 ± 10.1	47.3 ± 7.9	7.3 ± 9.9	0.72 (moderate) <sup>§</sup>	0.128
		Mean	9.4 ± 1.7	9.2 ± 2.6	-0.2 ± 2.6	-0.13 (unclear)	0.840
	D	Peak	31.4 ± 9.3	39.5 ± 8.0	8.1 ± 10.1	0.87 (moderate) <sup>§</sup>	0.056
		iEMG	38.1 ± 11.9	49.7 ± 16.0	11.7 ± 8.9	0.98 (moderate) <sup>§</sup>	0.024
		Mean	7.9 ± 2.1	9.9 ± 2.2	2.0 ± 2.1	0.95 (moderate) <sup>§</sup>	0.030
VL	ND	Peak	39.3 ± 11.0	36.8 ± 8.0	-2.5 ± 15.8	-0.23 (unclear)	0.717
		iEMG	47.3 ± 11.0	36.8 ± 8.0	-0.5 ± 18.0	-0.05 (unclear)	0.950
		Mean	9.4 ± 1.7	9.2 ± 2.6	-0.2 ± 2.6	-0.13 (unclear)	0.840
	D	Peak	37.0 ± 5.4	36.9 ± 8.2	-0.2 ± 10.0	-0.03 (unclear)	0.965
		iEMG	44.7 ± 10.1	47.2 ± 12.4	2.5 ± 10.2	0.25 (unclear)	0.545
		Mean	8.7 ± 1.8	9.0 ± 2.4	0.2 ± 1.8	0.13 (unclear)	0.725
RF	ND	Peak	24.7 ± 4.5	22.7 ± 2.5	-2.0 ± 5.7	-0.44 (unclear)	0.482
		iEMG	35.1 ± 6.8	33.0 ± 4.4	-2.1 ± 4.8	-0.30 (unclear)	0.391
		Mean	7.5 ± 1.0	7.0 ± 0.6	-0.6 ± 1.0	-0.54 (unclear)	0.279
	D	Peak	29.6 ± 11.0	25.2 ± 8.7	-4.3 ± 4.3	-0.39 (small) <sup>§</sup>	0.135
		iEMG	39.0 ± 10.0	36.1 ± 5.8	-3.0 ± 4.6	-0.30 (unclear)	0.287
		Mean	7.3 ± 1.3	6.7 ± 0.7	-0.7 ± 0.6	-0.51 (small) <sup>§</sup>	0.137
BF	ND	Peak	37.2 ± 11.9	39.2 ± 8.6	1.9 ± 6.0	0.16 (unclear)	0.514
		iEMG	42.8 ± 11.7	42.8 ± 6.7	-0.9 ± 9.3	-0.08 (unclear)	0.830
		Mean	7.9 ± 2.0	8.4 ± 1.5	0.5 ± 1.1	0.25 (unclear)	0.351
	D	Peak	42.0 ± 5.2	38.5 ± 3.3	-3.5 ± 3.2	-0.67 (moderate) <sup>§</sup>	0.120
		iEMG	42.7 ± 5.1	40.7 ± 4.7	-2.1 ± 3.3	-0.41 (unclear)	0.303
		Mean	7.6 ± 1.3	7.4 ± 1.4	-0.6 ± 0.3	-0.36 (small) <sup>§</sup>	0.044
VM:VL	ND	Peak	81.6 ± 8.0	99.2 ± 12.2	17.6 ± 19.8	2.20 (very large) <sup>§</sup>	0.118
		iEMG	82.2 ± 16.0	102.4 ± 18.3	20.1 ± 24.2	1.26 (large) <sup>§</sup>	0.097
		Mean	76.8 ± 11.0	95.4 ± 14.2	18.6 ± 22.8	0.95 (moderate) <sup>§</sup>	0.088
	D	Peak	75.1 ± 14.7	107.2 ± 29.2	32.1 ± 18.8	2.19 (large) <sup>§</sup>	0.009
		iEMG	84.9 ± 14.0	107.7 ± 26.0	22.8 ± 16.6	1.63 (large) <sup>§</sup>	0.020
		Mean	91.9 ± 19.6	115.6 ± 27.7	23.7 ± 23.4	1.21 (large) <sup>§</sup>	0.029
RF:BF	ND	Peak	68.0 ± 21.8	58.8 ± 18.7	-9.1 ± 6.5	-0.42 (small) <sup>§</sup>	0.021
		iEMG	85.6 ± 19.8	80.7 ± 16.0	-5.0 ± 13.1	-0.25 (unclear)	0.445
		Mean	99.5 ± 22.8	85.5 ± 17.2	-14.0 ± 7.8	-0.62 (moderate) <sup>§</sup>	0.016
	D	Peak	69.5 ± 18.8	65.4 ± 20.2	-4.1 ± 8.1	-0.22 (unclear)	0.388
		iEMG	91.6 ± 23.6	89.5 ± 18.2	-2.1 ± 5.7	-0.09 (trivial)	0.514
		Mean	93.9 ± 23.6	91.6 ± 18.2	-2.3 ± 5.5	-0.10 (trivial)	0.456

*Note.* An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and

635 small negative effects (i.e., 5%). §Probability of the effect exceeds 75% and is ‘likely’ to be  
636 clinically meaningful.

**Table 5.** Mean (%<sub>max</sub>), peak (%<sub>max</sub>), and integrated EMG (iEMG, %<sub>max</sub>) signal values (mean ± SD) for the *vastus medialis* (VM), *vastus lateralis* (VL), *rectus femoris* (RF), and *biceps femoris* (BF) muscles in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 200 W cycling efforts for the dominant (D) and non-dominant (ND) sides. The VM-to-VL and RF-to-BF activation ratios are also presented. Differences between conditions are expressed using mean change ( $\Delta_{\text{mean}}$ ); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ( $P \leq 0.05$ ) are highlighted in grey.

Muscle	Side	EMG	NT	KTT	$\Delta_{\text{mean}}$	ES (threshold)	<i>P</i>
VM	ND	Peak	39.4 ± 9.4	48.0 ± 4.4	8.6 ± 12.7	0.92 (moderate) <sup>§</sup>	0.122
		iEMG	<b>58.2 ± 9.6</b>	<b>68.1 ± 5.7</b>	<b>9.9 ± 7.7</b>	1.04 (moderate) <sup>§</sup>	<b>0.014</b>
		Mean	10.7 ± 1.5	12.1 ± 1.8	1.4 ± 1.8	0.92 (moderate) <sup>§</sup>	0.088
	D	Peak	47.0 ± 9.4	48.2 ± 5.3	1.2 ± 10.9	0.13 (unclear)	0.741
		iEMG	69.1 ± 10.7	70.1 ± 6.2	1.0 ± 11.4	0.09 (unclear)	0.830
		Mean	13.0 ± 2.4	14.1 ± 1.7	1.1 ± 3.0	0.46 (unclear)	0.380
VL	ND	Peak	46.4 ± 9.5	47.7 ± 6.2	1.3 ± 12.4	0.13 (unclear)	0.797
		iEMG	66.4 ± 6.9	68.9 ± 11.5	2.5 ± 13.7	0.37 (unclear)	0.643
		Mean	12.8 ± 1.8	12.8 ± 3.2	0.1 ± 2.2	0.05 (unclear)	0.924
	D	Peak	50.2 ± 7.0	47.7 ± 9.0	-2.6 ± 9.3	-0.37 (unclear)	0.433
		iEMG	65.8 ± 8.1	69.4 ± 9.0	3.6 ± 9.4	0.45 (unclear)	0.284
		Mean	13.0 ± 1.6	13.1 ± 2.1	0.1 ± 1.7	0.09 (unclear)	0.831
RF	ND	Peak	34.4 ± 12.6	37.1 ± 2.5	2.8 ± 14.5	0.22 (unclear)	0.657
		iEMG	54.4 ± 15.9	53.7 ± 6.7	-0.7 ± 15.1	-0.04 (unclear)	0.906
		Mean	11.9 ± 3.0	11.9 ± 1.7	-0.1 ± 3.4	-0.02 (unclear)	0.971
	D	Peak	39.5 ± 10.1	40.8 ± 6.6	1.3 ± 7.2	0.13 (unclear)	0.672
		iEMG	62.1 ± 11.9	63.7 ± 7.8	1.6 ± 13.6	0.14 (unclear)	0.761
		Mean	11.6 ± 1.7	11.4 ± 1.8	-0.2 ± 2.2	-0.11 (unclear)	0.844
BF	ND	Peak	42.6 ± 11.6	45.1 ± 6.4	2.6 ± 16.0	0.22 (unclear)	0.711
		iEMG	57.8 ± 12.9	58.8 ± 8.7	1.0 ± 12.9	0.08 (unclear)	0.846
		Mean	12.7 ± 4.8	12.2 ± 3.0	-0.5 ± 3.7	-0.11 (unclear)	0.735
	D	Peak	44.1 ± 8.1	38.5 ± 5.9	-5.6 ± 6.2	-0.69 (moderate) <sup>§</sup>	0.077
		iEMG	52.8 ± 13.1	52.8 ± 6.8	0.0 ± 13.4	-0.01 (unclear)	0.999
		Mean	10.7 ± 3.1	9.6 ± 2.1	-1.0 ± 2.4	-0.34 (unclear)	0.338
VM:VL	ND	Peak	85.6 ± 8.5	97.6 ± 15.5	11.9 ± 17.6	1.41 (large) <sup>§</sup>	0.157
		iEMG	87.8 ± 12.8	101.5 ± 20.9	13.7 ± 20.3	0.88 (moderate) <sup>§</sup>	0.124
		Mean	84.6 ± 6.8	98.7 ± 21.5	14.2 ± 19.2	2.07 (very large) <sup>§</sup>	0.098
	D	Peak	94.8 ± 19.3	98.5 ± 19.8	3.8 ± 27.2	0.20 (unclear)	0.707
		iEMG	96.6 ± 20.9	104.4 ± 18.3	7.8 ± 23.1	0.37 (unclear)	0.340
		Mean	100.2 ± 13.1	110.8 ± 27.9	10.6 ± 25.2	0.80 (unclear)	0.311
RF:BF	ND	Peak	82.6 ± 24.3	83.3 ± 9.7	0.7 ± 30.6	0.03 (unclear)	0.955
		iEMG	98.3 ± 34.4	92.9 ± 18.2	-5.3 ± 27.1	-0.16 (unclear)	0.620
		Mean	120.1 ± 34.2	106.7 ± 16.2	-13.4 ± 19.2	-0.39 (small) <sup>§</sup>	0.194
	D	Peak	92.5 ± 27.2	106.8 ± 17.0	14.3 ± 24.7	0.53 (unclear)	0.214
		iEMG	124.1 ± 36.9	121.5 ± 15.1	-2.7 ± 40.3	-0.07 (unclear)	0.867
		Mean	118.3 ± 43.9	121.8 ± 27.7	3.6 ± 37.6	0.09 (unclear)	0.825

*Note.* An effect was deemed ‘unclear’ when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). <sup>§</sup>Probability of the effect exceeds 75% and is ‘likely’ to be clinically meaningful.

648 **Figure captions**

649

650 **Figure 1.** Cyclist set-up for data collection with the patella kinesiology-type tape (KTT)  
651 applied.

652

653 **Figure 2.** Marker placement for 3D motion capture from anterior (left), posterior (middle),  
654 and lateral (right) views. Anatomical reference markers were placed bilaterally on the  
655 acromial processes, anterior superior iliac spines, posterior superior iliac spines, greater  
656 trochanters, medial and lateral femoral epicondyles, medial and lateral malleoli, and 1<sup>st</sup> and  
657 5<sup>th</sup> metatarsal heads. Tracking markers were placed bilaterally on the heel, mid-foot, and  
658 forefoot, and 4-marker rigid clusters were placed on the lateral aspect of the pelvis and  
659 bilaterally on the lateral aspects of the thighs and shanks. Anterior superior iliac spine,  
660 greater trochanter, femoral epicondyle, malleolus, and 1<sup>st</sup> metatarsal head markers were  
661 removed before the dynamic cycling efforts (red circles).

662

663 **Figure 3.** Ratings of comfort levels and perceived change in knee stability and cycling  
664 performance with the application of kinesiology-type tape (KTT) compared to no tape (NT)  
665 on a 5-point Likert scale. Data presented are the number of cyclists (*n*) that provided a given  
666 rating. Comfort level: 1, very uncomfortable; 2, uncomfortable; 3, no change; 4,  
667 comfortable; 5, very comfortable. Knee stability: 1, much less stable; 2, less stable; 3, no  
668 change; 4, more stable; 5, much more stable. Performance: 1, much worse; 2, worse; 3, no  
669 change; 4, better; 5, much better.